Evolving Diagnostic and Prognostic Imaging of the Cardiomyopathies

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Bluhm Cardiovascular Institute
Northwestern Memorial Hospital

No Relationships to Disclose
Cardiomyopathies:

• Echocardiography
• Cardiac magnetic resonance
• Cardiac computed tomography
Cardiovascular Imaging 2014

Echocardiography:

- Versatile
- Portable and available
- Relatively inexpensive
- Quantitative Doppler established and straightforward
- Transesophageal assessment
- Advances in 3D imaging
- Advances in TDI, contrast, speckle tracking, strain imaging
Cardiovascular Imaging 2014

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With advances in echocardiography, is there role for multimodality imaging in evaluating myocardial disease?
Hypertrophic Cardiomyopathy

Myocardial Scarring in Asymptomatic or Mildly Symptomatic Patients With Hypertrophic Cardiomyopathy

Lubna Choudhury, MD, MRCP, Heiko Mahrholdt, MD, Anja Wagner, MD, Kelly M. Choi, MD, Michael D. Elliott, MD, Francis J. Klocke, MD, MACC, Robert O. Bonow, MD, FACC, Robert M. Judd, PhD, Raymond J. Kim, MD, FACC

Chicago, Illinois

Choudhury et al, J Am Coll Cardiol 2002;40:2156-64
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Hypertrophic Cardiomyopathy

Occurrence and Frequency of Arrhythmias in Hypertrophic Cardiomyopathy in Relation to Delayed Enhancement on Cardiovascular Magnetic Resonance

A. Selcuk Adabag, MD, MS,* Barry J. Maron, MD,† Evan Appelbaum, MD,‡§ Caitlin J. Harrigan, BA,§ Jacqueline L. Buros, BA,§ C. Michael Gibson, MD, MS,‡§ John R. Lesser, MD,† Constance A. Hanna, RN,† James E. Udelson, MD,∥ Warren J. Manning, MD,‡§ Martin S. Maron, MD∥

Minneapolis, Minnesota; and Boston, Massachusetts

J Am Coll Cardiol 2008;51:1369-1374
Occurrence and Frequency of Arrhythmias in Hypertrophic Cardiomyopathy in Relation to Delayed Enhancement on Cardiovascular Magnetic Resonance

A. Selcuk Adabag, MD, MS; Caitlin J. Harrigan, BA; John R. Lesser, MD; Warren J. Manning, MD; Minneapolis, Minnesota; and J Am Coll Cardiol 2008;51:1369-1374.

LGE
No LGE

% Patients with Arrhythmias

NSVT
Couplets
PVCs
SVT

p<0.0001
p=0.001
p=0.007
p=0.07

n=177 patients

Adabag et al, J Am Coll Cardiol 2008;51:1369-1374
Prognostic Significance of Late Gadolinium Enhancement Imaging in Hypertrophic Cardiomyopathy

Rory O'Hanlon, MD,* Agata Grasso, MD,* Susan Clark, RN,* Ricardo Wage, * Jessica Halpern, Dana Dawson, MD, PhD,* Leena Sulai, MD, Chiara Bucciarelli-Ducci, MD,* Ferdinand Pezzilli, MD, William J. McKenna, MD,∥ Mary N. Shagiri, Dudley J. Pennell, MD,* Sanjay K. Prasad

London, United Kingdom

J Am Coll Cardiol 2010;56:867–74

n=217 patients

No LGE (n=81)

LGE (n=136)

p=0.006

Follow up (years)

Event free survival
Prognostic Significance of Late Gadolinium Enhancement (LGE) in Hypertrophic Cardiomyopathy

Rory O’Hanlon, MD,* Agata Grasso, MD,* Thomas J. Fioretti, MD, Susan Clark, RN,* Ricardo Wage, Jena Schaper, MD,* Dana Dawson, MD, PhD,* Leena Sulaihi, MD,* Chiara Bucciarelli-Ducci, MD,* Fernando K. Kalomenides, MD,* Gordon M. Dent, MD,* and F. Burger, MD,*

Mortality

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<th>Time (years)</th>
<th>Survival (%)</th>
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p=0.006

n=217 patients

LGE (n=148)
No LGE (n=72)

Myocardial Scar Visualized by Late Gadolinium Enhancement (LGE) on Magnetic Resonance Imaging Predicts Outcome: A Prospective Study of Events in Patients With Hypertrophic Cardiomyopathy

Oliver Bruder, MD,* Anja Wagner, MD,† Christian Hoff, MD,‡ Peter Ong, MD,§ Eva-Maria Kispert, RN,§ Karsten Schultz, MD,§ Georg V. Sabin, MD,* Udo Sechtem, MD,* and BRUCE R. L. M. M. ROBERTSON, MD, PhD, FRCP, FACC, FESC

Mortality

<table>
<thead>
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<th>Time (years)</th>
<th>Survival (%)</th>
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<tr>
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<tr>
<td>3</td>
<td>85.5</td>
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<tr>
<td>4</td>
<td>80.5</td>
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<tr>
<td>5</td>
<td>75.5</td>
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</table>

p=0.009

n=217 patients

LGE (n=148)
No LGE (n=72)
Prognostic Significance of Myocardial Fibrosis in HCM

- LGE absent
- LGE ≤ 10%
- LGE ≤ 15%
- LGE ≥ 20%

N=1293
P=0.008

Chan et al, Circulation 2014;130:484-495
Hypertrophic Cardiomyopathy

Indications for CMR

- Inconclusive echo for diagnosis or assessment of distribution of LVH
  - class I
- Define apical HCM
  - class IIa
- Late gadolinium imaging when risk stratification is inconclusive
  - class IIb
Differentiation of Ischemic and Dilated Cardiomyopathy

CAD

DCM

Cardiovascular Magnetic Resonance, Fibrosis, and Prognosis in Dilated Cardiomyopathy

Ravi G. Assomull, MRCP,*† Sanjay K. Prasad, MD, MRCP,*† Jonathan Lyne, MRCP,* Gillian Smith, MSc,* Elizabeth D. Burman, MSc,* Mohammed Khan, MSc, MPH † Mary N. Sheppard, MD, FRCPATH † Dudley J. Pennell, MD, FRCP, FESC †

London, United Kingdom

J Am Coll Cardiol 2006;48:1977–85

![Survival curve graph]

- Survival (percent)
- Time (days)

n=101 patients

- LGE− n=65
- LGE+ n=35

p=0.03
Association of Fibrosis With Mortality and Sudden Cardiac Death in Patients With Nonischemic Dilated Cardiomyopathy

Ankur Gulati, MD
Andrew Jabbour, MD, PhD
Tevfik F. Ismail, MD
Kaushik Guha, MD
Jahanzaib Khwaja, BSc
Sadaf Raza, MD
Kishen Morarji, MD
Tristan D. H. Brown, BSc
Nizar A. Ismail, BSc
Marc R. Dweck, MD
Elisa Di Pietro, MD
Michael Roughton, MSc
Ricardo Wage, DCR
Yousef Daryani, MD
Rory O’Hanlon, MD
Mary N. Sheppard, MD
Francisco Alpendurada, MD
Alexander R. Lyon, MD, PhD
Stuart A. Cook, MD
Martin R. Cowie, MD
Ravi G. Assomull, MD
Dudley J. Pennell, MD
Sanjay K. Prasad, MD

Gulati et al, JAMA 2013;309:896-908
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Kaushik Guha, MD
Jahanzaib Khwaja, BSc
Sadaf Raza, MD
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Sanjay K. Prasad, MD

Gulati et al, JAMA 2013;309:896-908
Novel Predictors of Left Ventricular Reverse Remodeling in Individuals With Recent-Onset Dilated Cardiomyopathy

Milos Kubanek, MD, PhD,* Marek Sramko, PhD, Jiri Weichet, MD, PhD,* Petr Lupinek, MD, PhD,* Josef Kautzner, MD, PhD*

Prague, Czech Republic

J Am Coll Cardiol 2013;61:54–63
Amyloidosis
CMR Imaging With Rapid Visual T1 Assessment Predicts Mortality in Patients Suspected of Cardiac Amyloidosis

James A. White, MD,*†‡ Han W. Kim, MD,§|| Dipan Shah, MD,# Nowell Fine, MD,*
Ki-Young Kim, MD,§ David C. Wendell, PhD,§ Wael Al-Jaroudi, MD,§
Michele Parker, MS,§|| Manesh Patel, MD,|| Femida Gwadry-Sridhar, PhD,‡
Robert M. Judd, PhD,§|| Raymond J. Kim, MDchnitt

London, Ontario, Canada; Durham, North Carolina

J Am Coll Cardiol Img 2014;7:143–56
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Marianna Fontana, MD; Silvia Pica, MD; Patricia Reant, MD, PhD;
Amna Abdel-Gadir, MBBS; Thomas A. Treibel, MBBS; Sanjay M. Banypersad, MBChB;
Viviana Maestrini, MD; William Barcella, BFIN, MSc; Stefania Rosmini, MD; Heerajnarain Bulluck, MBBS;
Rabia H. Sayed, MBBS; Ketna Patel, MBBS; Shameem Mamhood, MBBChBAO;
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Helen J. Lachmann, MD; Stuart G. Elwood, MBBS; Eric B. Schelber, MD; and Jonathan J. Valente, MD.
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Myocarditis

Hypertrophic cardiomyopathy

Dilated cardiomyopathy

Ischemic cardiomyopathy

Amyloidosis

Sarcoidosis

Myocarditis
Equilibrium Contrast Cardiovascular Magnetic Resonance for the Measurement of Diffuse Myocardial Fibrosis
Preliminary Validation in Humans

Andrew S. Flett, MB, BS, BSc; Martin P. Hayward, MBBS, BSc, MS;
Michael T. Ashworth, MD; Michael S. Hansen, PhD; Andrew M. Taylor, MD;
Perry M. Elliott, MB, BS, MD; Christopher McGregor, MD; James C. Moon, MB, BCh, MD

*Circulation. 2010;122:138-144*
Native T1 Mapping in Differentiation of Normal Myocardium From Diffuse Disease in Hypertrophic and Dilated Cardiomyopathy

Valentina O. Punthmann, MD, PhD,* Tobias Voigt, PhD,† Zhong Chen, MD,* Manuel Mayr, MD, PhD,‡ Rashed Karim, PhD,* Kawal Rhode, PhD,* Ana Pastor, MD,* Gerald Carr-White, MBBS, PhD,* Reza Razavi, MD,* Tobias Schaeffter, PhD,* Eike Nagel, MD, PhD*

London, United Kingdom

J Am Coll Cardiol Img 2013;6:273-84
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Cardiovascular T2-star (T2*) magnetic resonance for the early diagnosis of myocardial iron overload

L. J. Anderson¹, S. Holden², B. Davis², E. Prescott³, C. C. Charrier¹, N. H. Bunce¹, D. N. Firmin¹, B. Wonke³, J. Porter², J. M. Walker² and D. J. Pennell¹

Eur Heart J 2001;22:2171-2179
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Eur Heart J 2001;22:2171-2179
Imaging

Cardiac T2* Magnetic Resonance for Prediction of Cardiac Complications in Thalassemia Major

P. Kirk, MB, MRCP; M. Roughton, MSc; J.B. Porter, MD, FRCP; J.M. Walker, MD, FRCP; M.A. Tanner, MB, MRCP; J. Patel, MB; D. Wu, MB; J. Taylor, MB; M.A. Westwood, MD, MRCP; L.J. Anderson, MD, MRCP; D.J. Pennell, MD, FRCP

*Circulation. 2009;120:1961-1968*

Heart T2* and Development of Heart Failure

<table>
<thead>
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<th>Time (days)</th>
<th>Patients Developing Heart Failure (%)</th>
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<td>240</td>
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<td>360</td>
<td>60</td>
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</tbody>
</table>

p<0.001
Arrhythmogenic Right Ventricular Dysplasia

Tandri et al. *J Am Coll Cardiol* 2005;45:e98
Arrhythmogenic Right Ventricular Dysplasia

McCrohon et al. *Circulation* 2002;105:1394
Arrhythmogenic Right Ventricular Dysplasia

McCrohon et al. *Circulation* 2002;105:1394
Usefulness of Electron Beam Computed Tomography Scanning for Distinguishing Ischemic From Nonischemic Cardiomyopathy

MATTHEW J. BUDOFF, MD, DAVID M. SHAVELLE, MD, DANIEL H. LAMONT, MD, H. TINA KIM, BS, PAMELA AKINWALE, JOHN M. KENNEDY, MD, BRUCE H. BRUNDAGE, MD, FACC

Torrance, California

J Am Coll Cardiol 1998;32:1173–8
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Torrance, California

Diagnostic Accuracy of Multidetector Computed Tomography Coronary Angiography in Patients With Dilated Cardiomyopathy

Daniele Andreini, MD, Gianluca Pontone, MD, Mauro Pepi, MD, Giovanni Ballerini, MD, Antonio L. Bartorelli, MD, FACC, Alessandra Magini, MD, Carlo Quaglia, MD, Enrica Nobili, MD, Piergiuseppe Agostoni, MD, PhD
Milan, Italy

J Am Coll Cardiol 2007;49:2044–50
Multimodality Imaging: Myocardial Disease

*Cardiac magnetic resonance:*
- HCM: morphology and fibrosis (prognosis)
- DCM: exclude prior MI
- DCM: function and fibrosis (prognosis)
- Sarcoid, amyloid: diagnosis
- Iron overload: diagnosis, therapy effect
- ARVD: accurate diagnosis
- Noncompaction: accurate diagnosis
Multimodality Imaging: Myocardial Disease

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**CT angiography:**
- DCM: exclude ischemic cardiomyopathy